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REPORT

CD NO.

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COUNTRY	China	DATE OF INFORMATION	1950
SUBJECT	Economic; Transportation - Rail, rolling stock		
HOW PUBLISHED	Monthly periodical	DATE DIST.	22 Jun 1953
WHERE PUBLISHED	Peiping	NO. OF PAGES	16
DATE PUBLISHED	1 Oct 1950		
LANGUAGE	Chinese	SUPPLEMENT TO REPORT NO.	

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SOURCE Jen-min T'ieh-tao, Vol II, No 10, 1950.

DIAGRAMMATIC METHOD FOR PLANNING USE OF LOCOMOTIVES

/Comment: This report gives the tentative plan for the use of locomotives drafted by the Operations Section of the Locomotive Headquarters, Ministry of Railways, People's Republic of China. The plan was promulgated by the Ministry as Serial Chung-chi No 457, and was reprinted in the Peiping Jen-min T'ieh-tao (People's Railways) Vol II, No 10, 1 October 1950. Charts and tables included in the source article are appended.

In addition, for ease of reference, the following glossary of symbols, terms, and expressions has been compiled:

Glossary of Symbols, Terms and Expressions

LW Number of working locomotives on regularly scheduled duty.

LS Number of locomotives undergoing Wn inspection each month.

Ls Number of locomotives undergoing Wn inspection each day.

PIR Periodic Inspection Rate. This refers to the number of locomotives undergoing periodic inspection and repair on any one day in the month, expressed as percentage of the combined number of working locomotives plus those under inspection and repair.

DK Daily kilometrage.

MK Monthly kilometrage.

LU Number of locomotives in use. This includes LW and other locomotives engaged in miscellaneous services, active or standby, but not locomotives undergoing inspection and repair.

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TO Inspection and thorough overhaul. To take place periodically after every 450,000 kilometers of operation.

Td Number of days required or allowed for a TO job.

MO Inspection and medium overhaul. To take place periodically after every 150,000 kilometers of operation.

Md Number of days required or allowed for a MO job.

An Class A inspection; careful, with attention to needed minor repairs; to take place periodically after every 50,000 kilometers of operation.

Ad Number of days required or allowed for an An job.

Wn Washing inspection. Primarily for washing out the boiler; to take place periodically after every 3,000 kilometers of operation.

Wd Number of days required or allowed for a Wn job.

PMK Total monthly kilometrage of passenger and mixed train locomotives.

FMK Total monthly kilometrage of freight locomotives.

Ld Number of laboring days per month in the repair shops. This is 31 minus the number of Sundays and holidays. In these computations, this is taken as 31 minus 4, or 27 days.

PIN The total monthly inspection and repair task, consisting of the sum of the number of inspection and repair jobs of all categories scheduled for the month.

PIn The total daily inspection and repair task, consisting of the sum of the quotients resulting from each individual item in PIN being divided by Ld.

TPI Total number of locomotives undergoing periodic inspection and repair of all categories on any one day in the month./

A. Definite Location of Terminal Points Between Divisions

A clear decision as to the location of the terminal points between the locomotive divisions of a railway line is considered a prerequisite for planning the use of locomotives. It is the basis for assigning the locomotives to the divisions, for estimating the volume of locomotive inspection and repair work, and for providing the required installations and equipment. Moreover, it is an important essential for raising the efficiency of locomotive operations. Accordingly, the location of the terminal points between divisions under the control of the respective railway bureaus deserves careful study and full consideration. Care should be taken to avoid having divisions which carry chiefly one-way traffic or which are of too great length. If possible and feasible, freight trains should be operated for a distance of roughly 100 kilometers in either direction from the mid-point of a division, running the locomotives in the form of a figure 8, as suggested on the following page.

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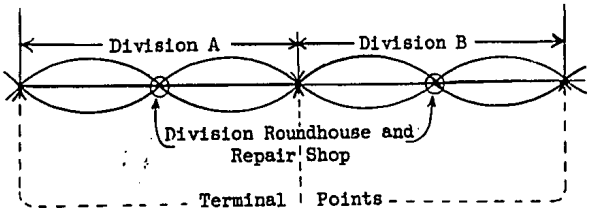

B. Assignment of Locomotives to Divisions

On the basis of the monthly records of traffic density in the course of a year, and after taking into account the number of pairs of trains, their speed, and the change of locomotives at the terminal points, the Ministry of Railways is able to calculate the number of locomotives that each railway bureau will require. This includes locomotives needed for passenger, mixed, and freight trains, for switching and standby service, as well as service locomotives, those that may be reserved for the use of the ministry, those on loan to another division or bureau, those undergoing cleaning, inspection, and repair, and those that may be in a state of wreckage.

Listings of the locomotives assigned to the respective divisions are published annually by the Ministry of Railways; and each month the ministry makes a study of the performance of the locomotives based on the reports from the various bureaus and divisions, noting particularly the daily kilometrage, speed, and turnaround time. These reports are prepared in two forms as shown in Table 1 and Table 2.

C. Method for Calculating Number of Locomotives Working, Under Inspection, Periodic Inspection Rate, and Efficiency of Operation

1. Working Locomotives (LW)

Working locomotives are those locomotives which are used daily for hauling the passenger, mixed, and freight trains on all of the divisions of each railway bureau. The determination of the number of locomotives needed depends upon the number of pairs of trains required to handle the volume of traffic. After the chiefs of the Locomotive Department and of the Operations Department have jointly decided on the number of trains needed, then the chief of the Locomotive Department will determine the number of working locomotives he must have to serve the trains to be scheduled in the light of the location of the terminus points between the divisions.

Among the objectives involved in determining the number of trains to be put into operation are: (a) reducing the periods spent waiting at terminal points; (b) raising the efficiency of utilization of rolling stock; and (c) economizing in the consumption of coal. This requires the close cooperation of both departments.

Based on the number of trains to be operated and the location of the terminal points, a Graphic Timetable for the locomotives can be drawn up for the different divisions of the line, as in Chart 1. The Ts'ang-hsien Locomotive Division /of the Tientsin -- P'u-k'ou Railway/, under the control of the Tientsin Railway Bureau, is used as an example. /Generally, throughout this article, the general principle involved is stated and then definite figures based on the Ts'ang-hsien division are used to illustrate the application of the principle./

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From Chart 1, a time schedule for the operation of the locomotives can be drawn up in the form shown in Table 3.

From Table 3 the following may be derived:

a. Complete round-trip time /average/ for locomotives in terms of hours. This is found by dividing by 5, (the number of pairs of trains), the sum of the round-trip traveling times, the delays at terminal points and at home station, plus the time spent working at terminal points and intermediate stations.

For the run from Ts'ang-shien to Te-hsien and back, the round-trip time is:

51 hr 22 min + 13 hr 28 min + 0 hr 40 min ÷ 5 = 13.1 hours.

For the run from Ts'ang-hsien to Tientsin and back, the round-trip time is:

65 hr 29 min + 11 hr 43 min + 1 hr 18 min ÷ 5 = 15.7 hours.

/Figures that do not appear on Table 3 were probably taken from the complete timetable./

b. Complete round-trip time /average/ for locomotives in terms of days and decimals thereof.

For the Ts'ang-hsien -- Te'hsien run, this is: $\frac{13.1}{24}$ = 0.55 days

For the Ts'ang-hsien -- Tientsin run, this is: $\frac{15.7}{24}$ = 0.65 days

c. Number of pairs of trains. For this division, there are ten pairs of trains.

d. Number of locomotives required. To obtain this figure, insert in Teble 4, the figures just found, namely: the round-trip time in terms of hours, the number of pairs of trains in each section of the division, and also, the figures to be derived therefrom.

e. Number of working freight locomotives required (LW). This is the product of the number of pairs of trains multiplied by the /average/ round-trip multiplied by 1.1; thus:

5 x 0.55 x 1.1 + 5 x 0.65 x 1.1 = 7 locomotives (LW)

/The text does not explain the factor 1.1; it is conjectured that it may represent the margin of standby locomotives that should be provided./

f. Daily kilometrage (DK) per freight locomotive. This is equal to the aggregate daily kilometrage of the freight locomotives divided by the number of freight locomotives that are necessary; that is:

$\frac{2,386}{6}$ = 397.7 kilometers (DK)

g. Actual running time. This is equal to the sum of the travel time between terminal points minus the sum of the stops at intermediate stations. (When formulating plans, the duration of the stops at intermediate stations may be found by referring to train timetables.) The timetable shows that stops by trains operating in the Ts'ang-hsien division amount to 42 hours; thus:

116.51 - 42 = 74.51 hours

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h. Running speed. This is equal to the total distance traveled divided by the actual running-time; that is:

$$\frac{2,386}{74.51} = 31.9 \text{ kilometers per hour}$$

2. Number of Locomotives in Use (LU)

Locomotives in use include working locomotives, line work or service locomotives, switching and delivery service locomotives, and standby locomotives. The Ts'ang-hsien division has one switching locomotive; hence the number of locomotives in regular daily use in the Ts'ang-hsien division is:

$$7 + 1 = 8 \text{ locomotives (LU)}$$

3. Monthly Kilometrage (MK)

The monthly kilometrage must include the total distance traveled per day by all of the following categories of locomotives: those hauling passenger, mixed, and freight trains; service, switching and delivery service locomotives; and locomotives running without loads.

For the Ts'ang-hsien division, this is 2,386 kilometers per day for freight locomotives plus 198 kilometers per day for the switching engines. For the monthly kilometrage, the sum of these must be multiplied by 31, thus:

$$(2,386 + 198) \times 31 = 80,104 \text{ kilometers (MK)}$$

4. Number of Working Locomotives Plus Those Undergoing Inspection (LW + Ls)

This is equal to the number of working locomotives, plus the number undergoing repair, which are needed in order that sufficient locomotives may be in good condition and ready at all times to maintain operations.

The following method is used to compute this combined number.

a. Number of locomotives undergoing inspection (LS and Ls):

$$LS = \frac{PMK}{Wn} + \frac{PMK}{Wn} \times Wd$$

For the Ts'ang-hsien division, the figures are:

$$LS = \frac{80,104}{3,000} \times 1.8 = 48.114 \text{ locomotives}$$

$$Ls = \frac{LS}{27} = 1.782 \text{ locomotives}$$

b. The number of locomotives working and undergoing (or due to undergo) Wn inspection is LW + Ls.

For the Ts'ang-hsien division, this is $7 + 1.782 = 8.782$, which must be taken as 9. (LW + Ls)

c. The number of days and hours, expressed decimally, required for completing the different categories of inspection, overhaul, and repair jobs, will depend on the men and facilities in the repair shops. The norm for each is determined by the master mechanic of the shop concerned.

For the Ts'ang-hsien division, as indicated in Table 5, the figures are:

$$Td = 20;\ Md = 15;\ An = 7;\ Wd = 1.8$$

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5. Periodic Inspection Rate (PIR)

The term periodic inspection rate refers to the number of locomotives undergoing periodic inspection and repair on any one day in the month, expressed in percentage of the combined number of working locomotives plus those under inspection and repair. Let TPI stand for the total number of locomotives undergoing periodic inspection and repair on any one day. Then this percentage, expressed by symbols as a fraction, will be:

$$PIR = \frac{TPI}{LW + TPI} \times 100$$

The calculation of PIR is made in five steps, in which the key figure still to be determined is TPI. Factors on which the result depends are the planned total monthly kilometrage of all the locomotives operating in the division (MK), and the kilometrages adopted by the Railway Bureau as standard for the frequency of the different categories of periodic inspection and repair. The latter are indicated by the symbols TO, MO, An, and Wn. [See glossary in Comment.]

a. Monthly inspection and Repair Tasks (PIN)

(1) For thorough overhaul, $\frac{MK}{TO}$, or $\frac{80,104}{450,000} = 0.178$

(2) For medium overhaul, $\frac{MK}{MO} - \frac{MK}{TO}$, or $\frac{80,104}{150,000} - \frac{80,104}{450,000} = 0.356$

(3) For Class A inspection, $\frac{MK}{An} - \frac{MK}{MO}$, or $\frac{80,104}{50,000} - \frac{80,104}{150,000} = 1.07$

(4) For washing inspection, $\frac{MK}{Wn}$, or $\frac{80,104}{3,000} = 26.7$

b. Daily Inspection and Repair Tasks (PIn) Using Above Figures

(1) For thorough overhaul, $\frac{0.178}{27} = 0.007$

(2) For medium overhaul, $\frac{0.356}{27} = 0.0132$

(3) Class A inspection, $\frac{1.07}{27} = 0.04$

(4) Washing inspection, $\frac{26.7}{27} = 0.99$

The sum of these items is:

1.05 locomotives (PIn)

All the appropriate data which is now available can now be entered in Table 5, and the relevant calculations carried out.

c. The number of days and hours, expressed decimally, required to complete the different classes of inspection, overhaul, and repair jobs on one locomotive, will depend on the men and facilities in the repair shops. The norms are determined by the master mechanic or chief of the divisional repair shop. They are the figures found in Column C of Table 5.

d. The total number of locomotives undergoing periodic inspection and repair, regardless of category, will be the sum of the individual daily tasks multiplied by the number of days required for each kind of task; that is, the figures in Column B multiplied by those in Column C, and then totaled. This total is seen to be 2.4 (TPI). See Column D in Table 5.

e. Periodic Inspection Rate (PIR)

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For the fifth and final step, the acquired values in the formula already mentioned can now be written:

$$PIR = \frac{TPI}{LW + TPI} \times 100 = \frac{2.4}{8 + 2.4} \times 100 = 23.1 \text{ percent}$$

f. The pertinent figures that have been acquired can now be properly entered in Table 1 and Table 2.

g. Taking into consideration the volume of traffic to be handled in the division, the railway bureau, will decide the proper number of stand-by locomotives that should be assigned to the division. In no case should this be more than 20 percent of the number of working locomotives (LW). [The sum of LW and the standbys would, presumably, be the number to be entered in the total line of Column K of Table 5.]

D. Ten-Day Schedules

The 10-day planning schedules are the chief basis for the daily and monthly schedules. They are designed to be more concrete than the monthly plans. This method serves to assure a constant supply of locomotives, regular periodic inspections, and improvement of management and operations in general, both in the offices and on the line. The best procedures for implementing the 10-day schedule are as follows:

1. The Traffic Department and the Locomotive Department of the bureau, in the light of the planned volume of traffic, should jointly determine the number of trains to be operated, decide on the number of working locomotives to be assigned to each division, as well as how many, and which locomotives are to be sent to the workshops for periodic inspections and repairs. The substance of these decisions should be communicated to the subbureaus for execution 24 hours before the commencement of the 10-day period.

2. The subbureaus, in conformity with the orders received from the bureau, will work out the round-trip assignments of working locomotives for passenger, mixed, and freight trains, and the schedule for locomotive repair jobs, similar to the arrangement in Table 3, and will instruct the divisions to operate accordingly.

3. Each division, following these instructions, should then work out three schedules; (a) the schedule for supply of working locomotives, (b) the schedule of shifts and taking over of duties by the locomotive crews, and (c) the schedule for withdrawal of locomotives for washing inspections. In making out these schedules, the identifying numbers of the locomotives assigned to haul each train must be definitely indicated, as well as the identifying numbers of the trains each locomotive is scheduled to haul each day.

The method is further explained as follows:

a. Schedule for Supply of Working Locomotives (See Chart 2)

In Chart 2, there are vertical columns corresponding to the 24 hours of the day. The vertical lines forming these columns indicate the exact hour beginning with 1800 hours. The figures in the first left-hand column indicate the days for a period of more than 10 days. In the case of passenger and mixed train locomotives, a schedule could be made out for a period of a whole month. In the horizontal spaces, heavy black lines are drawn, with the addition of small figures at their ends indicating the number of minutes past the hour, to show the exact time of beginning and end of each duty period; heavily drawn figures indicate the train numbers which the locomotive is scheduled to haul. The beginning and the end of scheduled inspection and repair periods are also accurately indicated. One horizontal line indicates when train crew No 1 is on duty; two lines, crew No 2; three lines, crew No 3.

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b. Duty Schedule of Train Crews (See Table 7)

This schedule is based directly upon Chart 2 which may be considered the planned on-duty locomotive schedule. Its chief purpose is to schedule and plainly show the on-duty arrangements planned for each locomotive crew. Across the top of Table 7, are the days of the month. In the columns at the left are spaces in which to enter the locomotive numbers, and the names of the locomotive engineer, his assistant engineer, and the fireman, for each crew. Then, by referring to Chart 2, write, in the proper spaces of Table 7, the identifying numbers of the trains to be hauled by the respective locomotives, so that each crew may see at a glance when it is scheduled to be on duty and the numbers of the trains to be hauled on each tour of duty. Similarly, the times when locomotives are scheduled for washing inspection are indicated by the symbol Wn.

c. Locomotive Washing Inspection Schedule (See Table 8)

This table shows, according to the schedule, when locomotives are to be sent to the workshop for inspection and repair. The left-hand column indicates the repair-gang number; in this case there are only two gangs. The second column from the left indicates the locomotives to be processed. The numbers across the top are the days of the month. Thus, the table shows the dates locomotives hauling a given train (for example, Train No 413) will be detached and their inspection begun following their arrival at the division workshop station. The table also shows how many days are allowed for the process and when it must be completed. The division master mechanic and the chief of the Operations Department, jointly, work out this schedule on the basis of the Schedule for Supply of Working Locomotives, (Chart 2) post it, and put it into effect.

4. The above three schedules, having been jointly prepared after careful study and planning by the Locomotive Department and Operations Department of the division, are communicated to the Train Dispatcher's Office for execution. If any modification is necessary, it must be discussed and agreed to by all the parties concerned. Notice of any change must be given to the Train Dispatcher's Office, and its receipt acknowledged, on the day preceding the effective date of the change.

5. If the volume of cargo to be transported is substantially increased or diminished, involving a change in the use of the standard number of locomotives, the Railway Bureau, on the day preceding the change, should see that the subsidiary units, down to the Locomotive Department of the division are so informed.

E. Daily Schedules

The preparation of daily schedules is the most definite and important step in the implementation of the 10-day schedule and the monthly planning. Its preparation is based on the 10-day schedule in conjunction with the daily traffic movements. The following procedure should be observed.

1. Every day, before 1600 hours, the Traffic and Locomotive Departments should make up the plans for the next day in the manner of Chart 1, showing the connections at terminal points and indicating the types and identifying numbers of the locomotives to be used, and notify the Locomotive Department to act accordingly.

2. For more detailed procedures and directions concerning the preparation and implementation of the Daily Schedules, the Regulations and Statistics of Locomotive Operation issued by the Ministry of Railways should be consulted.

/Appended tables and charts follow:/

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Table 1. Monthly Report on Operating Efficiency and Turnaround Time for Freight Locomotives

Bureau	Daily Kilometrage	Running Speed (exclusive of stops)	Complete Turnaround Time
	397.7	31.9	0.6

Table 2. Monthly Report on Number of Locomotives of All Kinds in Use and Periodic Inspection Rate

Bureau	Working Locomotives (LW)			Working and Under Inspection (LW - Ls)			Periodical Inspection Rate (PIR)
	Pass & Mixed	Frt	Total	Pass & Mixed	Frt	Total	
		7	7		9	9	23.1%

Table 3. Locomotive Operating Schedule

Recurring Cycle System — Ts'ang-hsien Locomotive Division — Freight Trains

Work Periods	Tien-tsin	Ts'ang-Hsien	Te-Hsien	Distance (in km)	Complete Round-Trip Time: Travel Time	Standing*		Working at Stations	Total
1	6.14	413	13.14	113.5	7.00	1.00			
	1.04	814	14.14	238.6	10.50	2.06			
	3.10	329	14.10	"	11.00	2.38			
	3.50	372	16.48	"	11.02	3.30			
	7.20	371	18.48	"	11.28	2.44			
	12.16	414	21.32	"	14.44	2.33			
	14.49	813	2.52	"	12.03	4.11			
	17.00	322	7.03	"	9.57	2.12			
	19.12	413	4.56	125.1	9.44	--	1.18		
2	21.31	330	16.50	125.1	4.41	1.22			
	22.53	321	8.49	238.6	9.56	2.55			
	16.10	330	11.44	113.5	4.26	--	0.40		
				2,386.0	116.51	25.11	1.58	--	144.0

*Standing at terminal points and at inspection points.

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Table 4. Monthly Plan for Locomotive Supply

Divisions	Type of Locomotive	Sections of Divisions	Distance (km)	Round-Trip (hr)	Locomotives Necessary for One Round-Trip	No of Pairs of Trains	No of Working Locomotives				
							Passenger Mixed	Freight			Total
								Necessary	Auxiliary	Total	
Ts'ang-hsien Division	Mikado	Ts'ang-hsien Te-hsien	113.5	13.1	0.55	5		2.75			
	"	Ts'ang-hsien Tien-tsin	125.1	15.7	0.65	5		3.25			
-- Division	"										
	"										
-- Division	"										
Total								6.0	0.6	7	7

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Table 5. Calculation of Periodic Inspection Rate of Locomotives in Use

Classes of Inspection	A Monthly Inspection and Repair Work	B Average Daily Inspection and Repair Task	C No of Days Required for Job on One Locomotive	D Daily Number of Locomotives Undergoing Inspection and Repair Jobs. (TPI) ColB x Col	E Daily Number Repair Jobs Partially Combined
Thorough overhaul (TO)	0.178	0.007	20	0.14	0.338
Medium overhaul (MO)	0.356	0.0132	15	0.198	
Class A inspection (An)	1.07	0.04	7	0.28	2.063
Washing inspection (Wn)	26.7	0.99	1.8	1.782	
Total	28.304	1.05		2.4	2.4

Classes of Inspection	Computation Data F Total Monthly Kilometrage (MK)	G Average Daily Kilometrage (MK)/31	H Daily Average Kilometrage per Locomotive G/J	J No. of Locomotives in Use (LU)	K No. of Locomotives Assigned to the Division	L Periodic Inspection Rate (PIR) (in %)	M Remarks
Thorough overhaul (TO)						3.3	
Medium overhaul (MO)							
Class A inspection (An)						2.7	
Washing Inspection (Wn)						17.1	
Total	80,104	2,584	323	8		23.1	

NOTES: 1. Average daily kilometrage is figured on the total kilometrage of all locomotives in use.

2. Number of locomotives in use includes all kinds of locomotives: freight, passenger, mixed, switching, stand-by, and any reserved for use of the Ministry.

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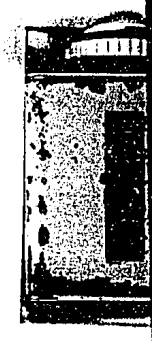

Table 6. Ten-Day Time Card of Train Crews

Locomotive Number	Crew No 1	Crew No 2	Crew No 3
	53	48	45

NOTE: The number of on-duty hours for each train crew in each 10-day period, which is indicated in the above table, includes the pre-departure and postarrival time of each run which is spent in checking the condition of the locomotive and in taking over from the preceding crew and turning over to the succeeding train crew.

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Table 7. Duty Schedule of Train Crews

Locomotive	ENGR	Asst. ENGR	FIREMAN	CREW	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mikado				1	413 814		372 371		813 322		Wm	814 329	371	371 414	322	413	Wm	Wm	329 372	372	414 813	
No 1061				2		814 329	371	371 414	322	413	Wm	329 372	372	414 813	813	Wm	Wm	43 814		372 371		
				3		329 372	372	414 813	813	Wm	413 814		372 371		813 322	Wm	Wm		814 329	371	371 414	
Mikado				1		372 371		813 322		Wm	814 329	371	371 414	322	413	Wm	Wm	329 372	372	414 813	813	
No 1516				2	814 329	371	371 414	322	413	Wm	329 372	372	414 813	813	Wm	Wm	413 814		372 371		813 322	
				3	329 372	372	414 813	813	Wm	413 814		372 371		813 322	Wm	Wm		814 329	371	371 414	322	
Mikado				1	372 371		813 322		Wm	814 329	371	371 414	322	413	Wm	Wm	329 372	372	414 813	813	Wm	
No 1540				2	371	371 414	322	413	Wm	329 372	372	414 813	813	Wm	Wm	413 814		372 371		813 322	Wm	
				3	372	414 813	813	Wm	413 814		372 371		813 322	Wm	Wm		814 329	371	371 414	322	413	
Mikado				1		813 322		Wm	814 329	371	371 414	322	413	Wm	Wm	329 372	372	414 813	813	Wm	413 819	
No 1532				2	371 414	322	413	Wm	329 372	372	414 813	813	Wm	Wm	413 814		372 371		813 327	Wm		
				3	414 813	813	Wm	413 814		372 371		813 372	Wm	Wm		814 329	371	371 414	322	413	Wm	
Mikado				1	813 322		Wm	814 329	372	371 414	322	413	Wm	Wm	329 372	372	414 813	813	Wm	413 814		
No 1645				2	322	413	Wm	329 372	372	414 813	813	Wm	Wm	Wm		372 371		813 322	Wm		814 329	
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STAT

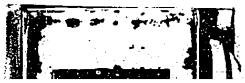

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Table 8. Locomotive Washing Inspection Schedule

Repair Gang	DATE / Locomotive	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Mikado 1061						413	413					413	—	413
2	" 1516					413	413					413	—	413	
1	" 1540				413	413					413	—	413		
2	" 1532			413	413					413	—	413			
1	" 1645		413	413					413	—	413				
2															
1															
2															
1															
2															

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Chart 1. Graphic Timetable

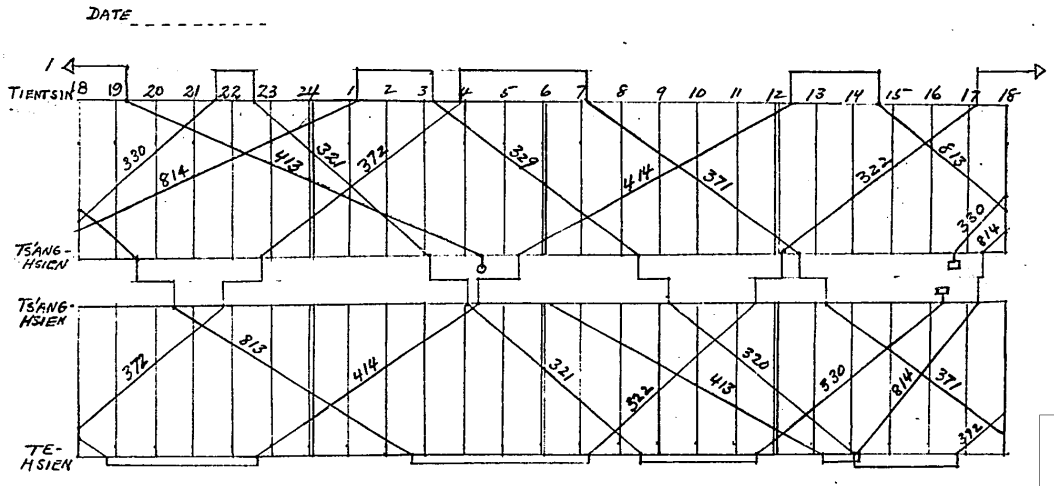

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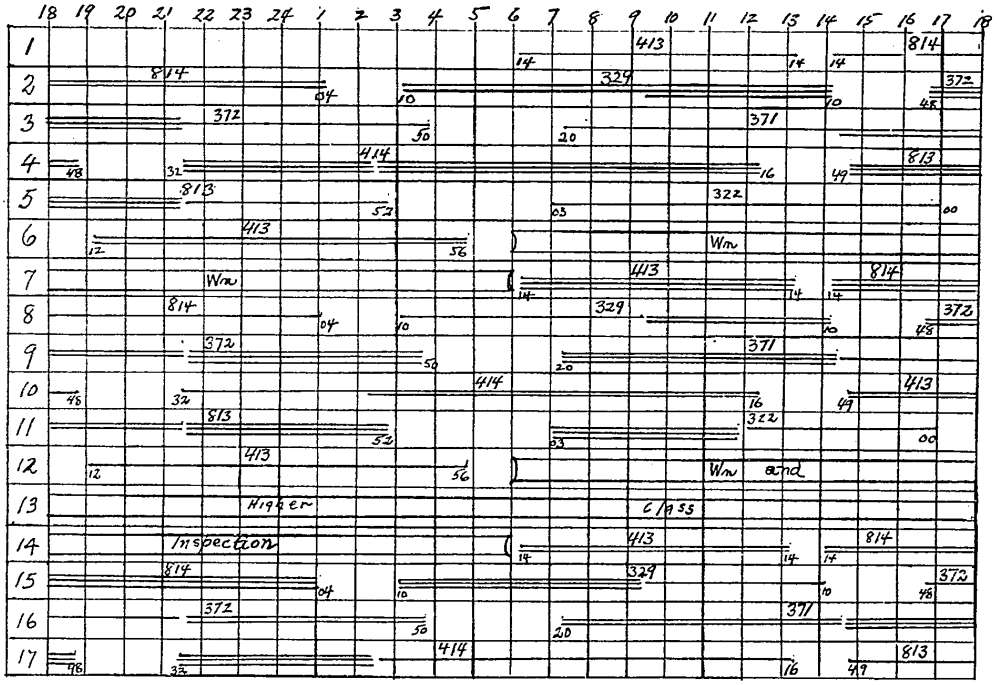
Chart 2. Diagram of Schedule for Supply of Working Locomotives



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